the twenty years of his residence amongst us. That he should have been allowed to depart was nothing short of a national calamity.

As regards British contributions to chemistry during this and the succeeding decade, the most noteworthy may be said to have emanated from the Oxford Street institution. Williamson, however, was still active at University College, and to this period belongs Frankland's recognition, in 1851, of the principle of valency. The synthetic colour industry originated in 1856 from Perkin's discovery of mauve, and Hofmann himself, with other of his pupils, contributed greatly to its development. As regards other workers, notable contributions to chemical theory at about this time were Clausius's work on electrolysis, Deville's studies on dissociation, Couper's conception of atomic linkage, and the resuscitation by Cannizzaro of Avogadro's hypothesis and his demonstration of its sufficiency at the memorable Congress of Karlsruhe in 1860. The introduction of spectrum analysis by Bunsen and Kirchhoff belongs also to this epoch.

NATURE was founded at a time of extraordinary development in chemistry. Kekulé had made known his fruitful conception of the constitution of benzene, and a host of workers, more particularly in Germany, were exploiting with feverish activity the chemistry of the so-called aromatic compounds. The synthetic colour industry received a remarkable impetus by the synthesis of alizarin. Newlands had already adumbrated Mendeléeff's great generalisation, of which the validity seemed to be established by the dramatic discovery, in quick succession, of the new elements it had predicted.

During the fifty years of its subsequent existence this journal has recorded and made intelligible to the general public every notable advance in chemistry. It has witnessed great and fundamental changes in the science. New conceptions have arisen and time-honoured doctrines have been modified or altogether supplanted. Chemical knowledge has been augmented by the inclusion of the theories of stereo-isomerism, desmotropy, the gaseous theory of solutions and free ions, and the Walden inversion. It has had to note and describe the methods of liquefaction of all the so-called permanent gases, and it has seen the universal recognition of the principles, first indicated by Andrews, on which the change of physical state depends. It has chronicled the discovery of argon by Rayleigh, and that of terrestrial helium, krypton, neon, and xenon by Ramsay. It has seen the rise and progress of radio-activity, the isolation of radium and its associates, and the discovery of isotopic elements. Lastly, it has seen a profound change in our conception of the Daltonian atom as an indivisible entity, and a strengthening of our belief in the intimate connection between matter and energy.

Throughout the whole of its existence NATURE has been true to the ideals which it established at its birth, and has been consistently faithful to the traditions it created. It has insisted from the outset that national progress must be based upon new ideas, and that the main source of new ideas is original research. It has shown that the greatest practical realities of our time have originated from the search for truth; that invention waits upon discovery—the most powerful of all agents of civilisation; and that new knowledge means new power. Hence it has with a uniform insistence pointed out that it is the duty of the State, in its own interest, to encourage and foster research and to remove the hindrances which beset the pursuit of science and impede its progress. Nor has its advocacy been based solely on the lower ground of material advantage, or on the fact that original research has proved to be the source of new industries and of wealth—that it creates employment and alleviates labour. It has striven to show that mental and moral progress have a scientific basis—that our knowledge of Nature and the universe, our modes of thought, our criteria of truth, our detection and avoidance of fallacies, are dependent upon that habit of mind we call "scientific"—a habit which can be cultivated and strengthened only by the study and pursuit of science.

It has a record of which it may justly be proud. By the manner in which it has discharged its functions and fulfilled its obligations, it has earned the gratitude of all men of science, and it now celebrates its jubilee with the knowledge that it has merited, and will receive, the unstinted appreciation of all true lovers of science.

CHEMISTRY IN THE MAKING.

By PROF. HENRY E. ARMSTRONG, F.R.S.

THE period covered by NATURE happens to be that which just comes within my ken. In chemistry, both pure and applied, it has been one of astounding progress and fulfilment. Frankland and I published our new method of water analysis—involving combustion *in vacuo* with the aid of the Sprengel pump—in the year of its birth: people then ran their sewage into a cesspit and drank the water from an adjoining well. Typhoid fever was rife throughout the land. Bacteriology was an unknown science. Frankland's work on the Rivers Commission gave the nation a pure-water supply and contributed greatly to a complete sanitary system, in this respect placing us ahead of the world. The systematic use of the Sprengel pump dates from our inquiry; Crookes afterwards used it in constructing his radiometers.

It is noteworthy that sulphuric anhydride was a laboratory curiosity at that time: when I prepared several pounds of it, in Leipzig, in the autumn of 1868, I was regarded with wonder: Squire and Messel began its manufacture here at Silvertown in 1873: it soon came into vogue, especially in the alizarin industry. During the war, many thousands of tons have been used in the production of propellants and high explosives. I then also made the chlorhydrol, SO_3HCl, in quantity, and suggested to my student friend, Karl Knapp, Liebig's nephew, that he should test its value as a sulphonating agent. He sulphonated benzene. I took up the work afterwards and first applied it to toluene, so laying the foundation of the method now preferred in manufacturing saccharin.

In 1868 chemists were waxing enthusiastic over Mendeléeff's great generalisation, brought home to us not only in his paper in the *Annalen* but also by Lothar Meyer's well-known book, then recently published, especially by Meyer's justly famed atomic volume curve. At that date those of us who could think in terms of systematic organic chemistry were possessed by the view that the "elements" must be compounds: the "periodic" inter-relationships were so similar to those manifest in homologous and isologous series. Soddy's "isotopes"—the word is unnecessary—are simply the chemist's homologues. That the two leads should be as like as the two Dromios—recent observation shows that they are perceptibly different—is in no way surprising: methane and ethane are all but indistinguishable chemically; we can also foresee isomeric as well as homologous primaries. Now that the "primaries" have been robbed of their position as "atomic" materials, by the appearance on the scene of radium, this view is proved to have been justified; but none of us ever dreamt that they would come to be regarded as made of lumps of electricity—still less that we should ever dare to think of energy in terms of quanta or to discard the doctrine of the other in favour of one of relativity.

All my life, I have regretted the aloofness of chemistry from physics: that the physicist shows so little real interest in chemistry. It is a welcome finish to find him at last entering upon the fringe of our domain and taking up our work, though it is a pity he cannot become one of us instead of a mere extrapolation; probably it cannot well be otherwise, as the mathematical habit of mind is required for the new work and chemist and mathematician are different natures. Ours must be the task of digesting the material to the point at which our mental enzymic machinery no longer suffices and that of the mathematician and physicist comes into play. The two recent lectures to the Chemical Society by Nicholson and Jeans—both astounding displays of eloquence and imaginative power—are demonstrative of the new departure. If fifty years hence the new field be as fully grasped as that has now been which I saw opening up in 1868, NATURE at its centenary will indeed have cause to congratulate its readers.

In 1868, we were only beginning to write C=12; our symbolic system was barely stabilised; the importance of Avogadro's theorem was but coming home to us, mainly through Cannizzaro's insistence. Structural constitutional chemistry was in its infancy. Frankland's theory of valency—it is now clear that he included carbon in his scheme—and Kekule's benzene symbol were new weapons; we were only beginning to interpret isomerism in terms of structure; we scarcely thought of position as its cause. A vast edifice has been erected in the interval but the foundations are simple: Frankland's postulates have but been supplemented by van't Hoff's extension of Pasteur's geometric conceptions. What is most noteworthy is the surprising simplicity and sufficiency of the system.

Latterly we have begun to think in terms of solid structure: it is already clear that the next advance will come from the geometric, crystallographic side: and having learnt to see through a brick wall, we are now beginning to peer directly into the molecular structure of crystalline solids. Low temperature phenomena have been probed to their depths, especially in this country; indeed, we have seen a series of important industries grow out of the work.

The growth of our knowledge of method, of our analytic and synthetic powers, has been marvellous—full use has been made of this development by the manufacturer, so that we can now not only reproduce natural colouring matters but match the rainbow in every tint. Although British chemists cannot claim the credit of much of the matching, they can at least rejoice in the fact that the foundations were laid in London—by Faraday's discovery of benzene in 1825, in Albemarle Street; and by Perkin's discovery of mauve, in Oxford Street and at Sudbury in 1856.

It is noteworthy that mauve was made in attempting to synthesise quinine: as we are not yet certain as to the structure of this alkaloid and in no way near to a method of producing it artificially, it is clear that even now our powers of interrogating and copying Nature are but limited: remarkable as our progress has been, she yet defies us in many directions. We stand ashamed before the unassuming ease with which she fabricates starch from glucose underground in the dark; indeed, cane-sugar, starch, cellulose and not a few other compounds of primary importance are still to be ranged with the Delphic mysteries.

But whilst, on the organic side, we have secured a wonderful mastery and the odds in favour of our structural conceptions are many thousands to one—because we have been able to ring the changes so often with success; on the inorganic side, almost complete ignorance prevails—because we have not been able to ring the changes. Thus we cannot say, with any approach to certainty, what is the structure of so simple a substance as sulphuric acid. In this and similar cases probably the clue will come through X-rays.

On the biological side the advance has been very great and it can no longer be said with truth that "Thierchemie ist Schmierchemie"—Emil

Fischer's expression; but physiologists are still far from being sufficiently schooled in our science and progress has been chiefly due to men such as Emil Fischer, who have had sympathy with biological problems and been alive to the fact that it is desirable to walk before running. It is strange that few chemists have biological leanings—but the biological is still further removed than the chemical from the mathematical habit of mind.

The chief feature of progress in later years has been the ongrowth of the physical school. This has had both its advantages and its disadvantages—for whilst we have been led to widen our vision and increase our grip on the philosophy of our subject, we have lost in manipulative skill, as we have given inadequate attention to the development of method and technique. This probably is one of the chief causes of our comparative failure on the industrial side. Though based on analysis, chemistry is mainly a constructive, practical science: our success has been in proportion to the extent to which we have been able to confirm analytic by synthetic results. The man who does always gets ahead of the man who doesn't—of the man who merely seeks to explain; though the latter is often more useful than is supposed in controlling practice. Still it is because fingers and artistry come first in the practice of chemistry, that the chemist proper is not and cannot often be a mathematician. The superior value of the preparative side has been so brought home to us during the war, that it is to be hoped that full attention will now be given to its development.

Our ill-balanced bookish system of examinations is one of the main causes of the incomplete practical training chemists have received of late years; we have yet to teach the real value of books, that they are meant for constant reference; to force students to memorise them is the worst of policies: thoughtful, dextrous fingers and knowledge of materials are the chemist's chief needs.

Much progress has been made, on the physical side, in correlating properties with structure. Also great attention has been paid to the problems of solutions: unfortunately the men who have dealt with this latter side of chemistry have not been working chemists—in fact, scarcely chemists at all—and the pseudo-mathematical treatment they have introduced has often savoured far too much of dogma. The result has been to introduce an unscientific, partial habit of mind into our subject. We are strangely behind in having no proper, accepted theory of chemical change in general. Our elementary text-books too are behind the times—full of half-truths and superficial when not inaccurate: there is no lack of detail but little philosophy and still less logic. Chemistry is the most fundamental of the sciences, the one by means of which it is alone possible to teach the principles and practice of scientific method in their entirety—and yet chemists are rarely trained to be masters of method.

To make chemistry a truly philosophical science, for the guidance of students, we need a man of giant mind, well versed in practice, who will survey and weigh the facts and give sympathetic consideration to all hypotheses, then summarise the situation in broad and simple terms which all can understand. Fitzgerald was a man of the type I have in mind.

Certainly the progress made during the fifty years is astounding—the extent of our collective knowledge is extraordinary. But we must be on our guard—there are too many "bits of chemist" about: the most pretentious member of the species is of modern invention—the "research chemist." No chemist is a chemist who is not fully imbued with the spirit of inquiry. Not a little of the work that is now called research is of a trivial character; the majority are incapable of original effort and far more careful direction of advanced work is required. If care be not taken, "research" will become a word of reproach. The effort of the future must be to produce the whole chemist—the man who will know his subject and be ever careful and modest, both in word and deed, being possessed by scientific method.

THE DISCOVERY OF CHEMICAL ELEMENTS SINCE 1869.

BY PROF. H. B. DIXON, F.R.S., AND H. STEPHEN, M.Sc.

A GLANCE at the history of the chemical elements reveals the fact that no fewer than fifty-three of them were recognised so early as 1818, and since that time some thirty more have been discovered. The search for new elements between 1818 and 1869 represents an empirical programme without considerations of marked theoretical interest, and the investigations were directed more particularly to an examination of minerals. The chief results were the isolation of new metallic elements, and the work of the great master, Berzelius, stands out pre-eminently during this period, and his quantitative work surely paved the way for future investigations.

The later period extending over the past fifty years marks out a new era in the history of the chemical elements, inasmuch as it opened with the discovery of the periodicity of the elements in connection with their atomic weights. The elaboration of the system in its final form was due to Mendeléeff in 1869, although Newlands had foreshadowed such a system in his law of octaves (1863).

Mendeléeff's system had a profound effect in bringing about radical changes in respect of the atomic weights of certain elements, notably beryllium, uranium, and indium; and in affording predictions of the existence and properties of new